Energy efficient housing to benefit South African households

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Efficacité énergétique des maisons et leur apport aux ménages en Afrique du Sud
Les ménages pauvres en Afrique du Sud consacrent une grande partie de leur revenu pour satisfaire les besoins d'éclairage, cuisson, et chauffage. Le charbon et le bois, sources d'énergie particulièrement polluantes, sont utilisés pour les besoins de chauffage. Une architecture prenant en considération l'efficacité énergétique permettrait de réduire substantiellement la consommation d'énergie domestique tout en maintenant la même qualité de service. Des mesures relativement simples comme l'orientation des maisons, toitures et planchers adaptés peuvent apporter des avantages conséquents aux ménages. Ces mesures permettraient de diminuer les dépenses de chauffage tout en contribuant à améliorer la qualité de l'air à l'intérieur des maisons et à réduire les émissions des gaz à effet de serre.

Introduction

Poor households in South Africa spent a large proportion of their income on energy services, for lighting, cooking and heating their houses. In particular, space heating is mostly done using fuels like coal and wood, which cause indoor air pollution.

By designing houses with energy efficiency in mind, the amount of energy needed to keep the house comfortable can be reduced dramatically. Typically, the low cost housing provided for those on small incomes in South Africa are of poor quality, with inferior thermal performance characteristics. Relatively simple interventions like orientation for new houses (the direction which the property faces), or providing ceilings in existing houses, can bring huge benefits to the inhabitants. These benefits are not only in the form of reduced expenditure on space heating fuels, but also on improved indoor air quality, as well as global benefits accrued by reducing the emission of greenhouse gases, such as CO_2.

Passive solar design

Passive solar design involves applying energy flow principles and climate characteristics of a region in the design, construction and management of houses, so as to achieve thermal comfort with minimal conventional energy input. The basic components of passive solar design incorporate the orientation of the house, optimising the use of direct natural sunlight, and utilising thermally efficient building materials. Applying these principles provides a low cost or no cost intervention and is applicable in all climatic regions.

Orientation of the house

Passive solar design can reduce the energy requirements to keep the house comfortable. It implies that houses in the Southern Hemisphere should face towards geographic north (±15°) in order to obtain optimal solar benefit. Houses which point north have most windows facing north, would have the least heat gain in summer and the least heat loss in winter, keeping the indoor air temperature comfortable. The orientation of houses should be an integral part of planning and design and any deviation from this rule should be for a good reason.

Building materials

Passive thermal design also entails using appropriate building materials, such as materials with a high thermal

Figure 1 Principles of passive solar design (source: IIEC – Passive Solar Design Brochure)

Table 1 Overview of projects targeting energy efficiency in low cost housing in South Africa (Klunne 2002)

name of project	province	rural/ urban	density	number of houses	other sustain-ability aspects	orientation	roof overhang	ceiling	wall insulation	alternative materials	user education	new/ retrofit	energy moni-toring
All Africa Games Village	Gauteng	urban	medium	1799	yes	yes	partially	yes	no	no	no	new	no
Krugersdorp Housing project	Gauteng	urban	low	18000	yes	yes		yes	no	no		new	no
Kutlwanong Eco-housing project	N. Cape	urban	low	200	no	yes	yes	yes	yes	no	yes	new	partially
Ivory Park, mud brick house	Gauteng	urban	low	1	yes	yes	partially	yes	no	yes	yes	new	no
Ivory Park insulated ceiling	Gauteng	urban	low	30	no	no	no	yes	no	yes	yes	retrofit	no,
Mohlakeng, Ext. 2, Randfontein	Gauteng	urban	medium		yes	yes		yes	no	no	yes	new	no
Thermally improved shacks, Mabopane	Gauteng	urban	shacks		no	no	no	no	yes	yes		retrofit	yes
SEED housing Cape Town	W. Cape	urban	low	2300	yes			yes				new	no
Tlholego, Rustenburg	North West		rural	low	yes	yes	yes		no	yes	yes	new	no
Alexandra East Bank Housing Development	Gauteng	urban	low	1200	no	yes	no	no	no	no	no	new	no
SOWETO eco home	Gauteng	urban	low	1	yes	yes	yes	yes		no		new	ongoing
Shayamoya – Cato Manor, Durban	KZ Natal	urban	medium	320	yes	yes	no	no	no	no	no	new	no
Missionvale, Port Elizabeth	KZ Natal	urban	medium		no	no	no	no	no	no	no	new	no
Waterloo Development	KZ Natal	urban	low	2	no					yes	yes	new	no
Dutch AIJ (Benoni, Kimberley, Cape Town, Lady Grey)	Gauteng N. Cape W. Cape Free State	urban	low	4 * 4	no	yes	yes	yes	yes	yes	no	new	ongoing

* low density refers to stand alone houses, medium density to multiple units combined in one physical structure

Theme

mass, which are able to store heat during the day and release this heat slowly at night. The current trend in low cost housing in South Africa is to use hollow cement blocks for walls and concrete flooring, which both have reasonable thermal capacities. Alternative materials such as earth bricks have much higher thermal capacities, but have been rejected by communities in earlier projects, as they are perceived to be inferior materials (Walker, 1999). Recently earth bricks seem to be enjoying better acceptance.

Position and size of glazing

Daylighting refers to optimizing natural sunlight through glazed areas during daylight hours in such a way that heat gain is minimized in summer and heat loss is minimized in winter (Irurah, 2000). Solar radiation transmitted through glass converts to heat when it strikes materials, such as concrete floors, and is then re-radiated as heat. According to Holm (1996), the size of glazing should be approximately 20% of the total floor area (exact figure depending on the climatic circumstances), on the northern side of a house for 'solar collection' to provide the most favourable thermal efficiency. There should also be a minimal window surface facing the south, east and west.

Double-glazing is a thermally efficient principle, which is a common practice in areas where winters are long and cold. In South Africa this technology is rarely used because of the prevailing English tradition of single glazing in residential housing coupled with the perception that energy is cheap.

In the inland areas of South Africa the material used for the window- and doorframes is metal, which conducts heat. In the coastal areas, where corrosion is a problem, wood is used. In general it can be said that wood provides a much better insulation than steel, but is seldom used inland because of the unavailability and cost of this material.

Roof overhang

The northern orientation of houses should be coupled with a roof overhang on the northern side of the houses throughout South Africa, designed according to the summer and winter angles of the sun. The size of the roof overhang depends on the roof geometry, but should be about half a metre in length to shade the northern windows from the sun during the summer months and to allow the sun's rays to penetrate in winter, when the sun is lower on the horizon (Garner, 1999). Roof overhang should ideally be combined with a strip of grass or vegetation around the houses to prevent the surface from warming up. This is a low to moderate cost intervention.

Ceilings

Installing ceilings is critical in order to achieve a thermally efficient low cost house. With their ability to trap air, ceilings ensure a reduction of heat flow into or out of the house. As a result, the house is warmer in winter and cooler in summer. The cost of a traditional ceiling is in excess of 37 Rand (US$3.7) per square metre (Baloyi 2000), while new innovative low cost ceiling can be as cheap as 18 Rand (US$1.85) per square metre. Ceiling insulation is a moderate to high cost intervention, but an absolute necessity.

Insulation

There are various methods to insulate a wall. Building a cavity wall (two parallel walls with an air gap between) is seen as the most effective method of insulation, but it is also the most expensive method and therefore not widely applied. Another method is to plaster walls, or to use panels (also called *construction boards*). These panels are either used as an add-on to the walls and thus function as in insulation layer or fulfil the wall function themselves and have a structural function.

Flooring

Floors are an important component to achieve thermal efficiency in houses. Flooring material should be of high thermal mass, such as concrete, bricks or clay, to trap heat and solar radiation coming in through the windows. The heat is slowly released at night. Single storey residential units can basically use the high thermal mass floor slabs and the soil underneath it as thermal mass. Multi-storey residential blocks have the disadvantage that they only have the ground floor with this thermal advantage. Adding thermal mass to upper storeys by adding heavyweight material beyond constructional requirements involves high costs and is often considered to be too expensive.

Shared walls

Shared walls, either in the form of a row of houses or semi-detached houses, saves on the costs of the housing shell as well as on energy consumption. When units share walls, they provide more insulation against heat loss in winter and heat gains in summer than the single housing units. However, some communities do not accept shared walls and argue that 'One must be able to walk around one's house, otherwise it is not a house'. Fortunately the new policy of the Department of Housing shows a shift from stand-alone units to multiple dwelling units.

Current energy-efficient housing initiatives

Various small and larger projects have been executed in South Africa, trying to address energy efficiency in residential housing. Many of them also include other aspects of sustainable living such as water or waste related issues. Unfortunately all these projects are stand-alone activities with limited or no interaction. Table 1 summarizes these projects.

Surprisingly none of these projects has been evaluated properly for the effect of the interventions on energy use, except for the Mabopane project on shacks. For houses, we have to judge the cost effectiveness of the interventions available, based on computer simulations. After the no-cost, or low-cost principles of passive solar design, ceilings with insulation are the most promising intervention, followed by insulating the wall by applying insulation material (like polystyrene) on the outside (Klunne, 2002).

What is needed?

Action is needed at two fronts. First, all new low cost houses to be built should feature at least the principles of passive solar design, supplemented by installation of a ceiling. On the other hand existing structures need to be made more energy efficient by installing ceilings or applying insulation material.

As such actions are currently not common practice, a support programme needs to be developed in which energy efficient houses are eligible for some type of financial incentive. The South African Department of Housing is currently developing such a program in collaboration with the GEF.

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